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WIND-SPEED FORECASTING STUDY for WESTOVER AFB, MASSACHUSETTS

by

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DECEMBER 1991

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13. Abstract: This report describes the results of a wind-speed forecasting study for Westover AFB, located in the Connecticut River valley of western Massachusetts. The study was requested by the 21st Air Force Directorate of Weather to identify useful tools for forecasting wind speeds at Westover AFB. The results were five models that can be used as guides to forecasting maximum Westover winds for 6-hour periods starting at any 3-hourly time (00Z, 03Z, etc.) in any season. Methodology is provided, along with a description of input data, verification of the models, and final results.

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PREFACE

This study describes the results of USAFETAC Project 900410, "Wind Study for Westover Air Force Base, Massachusetts." The analyst was Mr William R. Schaub, Jr, USAFETAC/DNO.

The study was based on a request from the 21st Air Force Directorate of Weather (21AF/DOW) at McGuire Air Force Base, New Jersey, which asked USAFETAC to develop a wind correlation study to help forecast Westover AFB surface wind speeds.

Specifically, 21AF/DOW asked that the pressure differences between three pairs of reporting stations near Westover AFB be correlated with hourly wind speeds (excluding gusts) in three wind direction categories: north or south, northwest or southeast, and west or east. To make the study complete, a southwest or northeast category was included, as well. Pressure differences were paired with wind speeds for correlations according to the four directional categories. Linear regression was used on 3-hourly data to obtain predictive equations for the maximum wind speed occurring within 6 hours of forecast start times of 00Z plus every 3 hours. The utility of an 11-millibar or greater pressure difference between any of the station pairs as an indicator of gusts equal to or greater than 35 knots was then evaluated.

The regression equations based on pressure differences showed limited skill in predicting wind speeds, and the 11-millibar pressure difference turned out to be a poor indicator of wind speeds at or above 35 knots. Therefore, the study was expanded to include more variables in the linear regressions. The highest observed wind speed at Westover at each 3-hourly forecast start time was used in combination with other variables to produce predictive equations for the maximum wind speed occurring within 6 hours from any 3-hourly start time.

Another technique was also developed and evaluated. This one compared 3-hourly pressure difference observations from two of the station pairs with the highest wind speeds observed at Westover during the 6 hours following each 3-hourly observation. Mean values of the highest wind speeds were evaluated as predictors of wind speed for 6 hours following each 3-hourly observation at the two pressure differences.

The study resulted in regression equations that showed skill in forecasting the highest wind speeds for 6-hour periods starting at 3-hourly times for all seasons. Five of these are recommended as guides in short-term wind forecasting for Westover.

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1. INTRODUCTION

1.1 Background. A common technique used to predict surface wind speed uses pressure differences between two stations in the area of interest as predictors. Since wind speed is dynamically related to the pressure gradient, weather forecasters often use the pressure difference between two points as an indicator of how strong the winds might be. Above the influence of surface friction at the *gradient level* (selected by convention as being 2,000 feet above ground level), the *gradient wind,* which is proportional to the pressure difference, provides an adequate estimate of wind speed. But when they are used alone to estimate surface winds, models using these differences have shown limited skill. For example, a recent study for Minot AFB, North Dakota, Miller (1990) showed that pressure difference is most helpful in predicting maximum surface wind speeds when used in linear regression equations with other variables.

1.2 Focus of the Study. This wind speed study was done for Westover AFB, which is in the Connecticut River valley of western Massachusetts. Weather forecasts for Westover are prepared by the 21st Air Force Directorate of Weather (the customer) at McGuire AFB, New Jersey. Figure 1 shows the area of interest and the weather reporting stations used in the study.

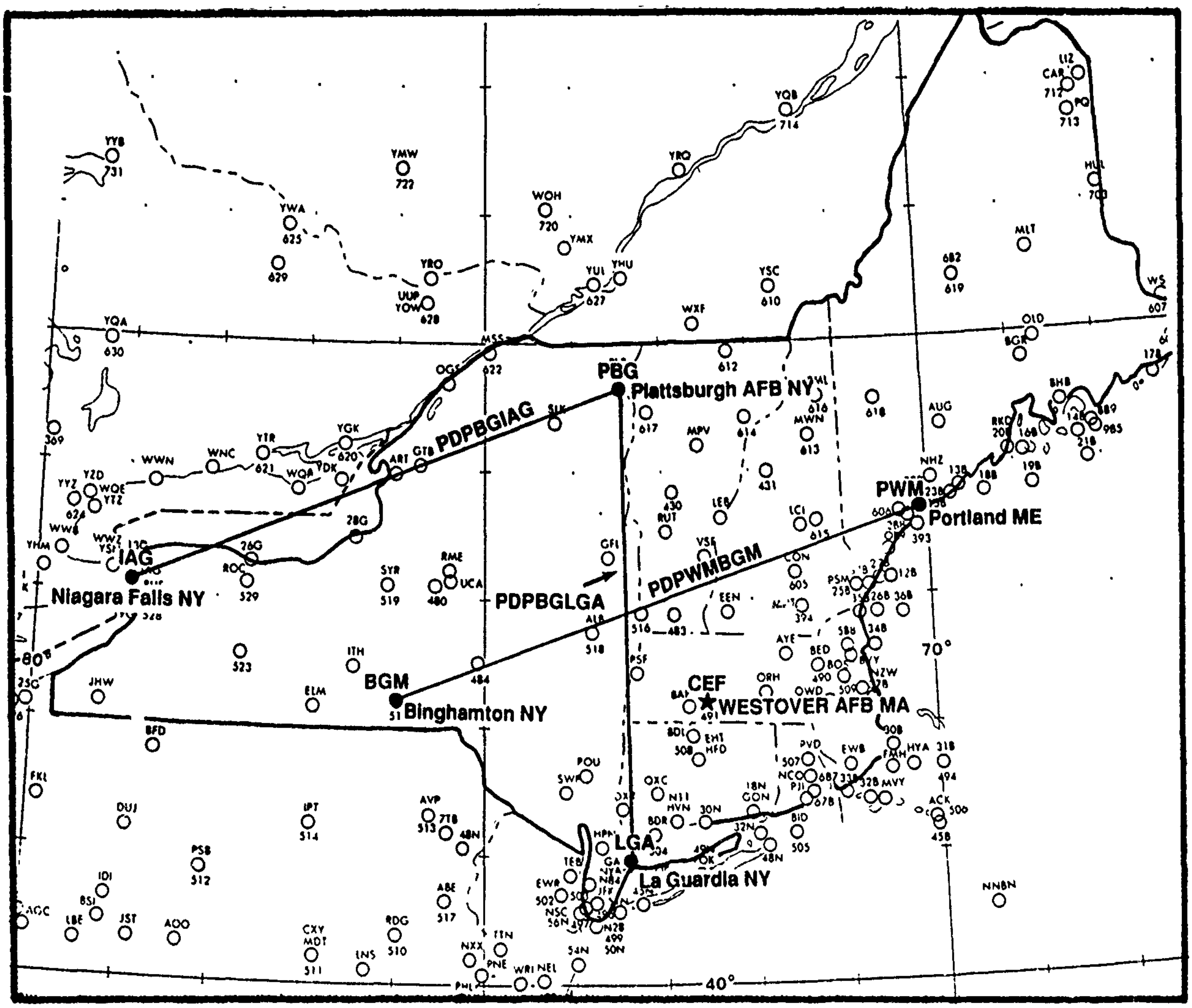

Figure 1. The Area of Interest, Showing Stations Used in the Westover Wind Study.

1.3 Basic Study Requirements. The customer asked for a study that correlates pressure differences and wind speeds between three pairs of reporting stations. We were asked to use pressure differences between Pease AFB, New Hampshire (PSM), and Binghamton, New York (BGM) for winds from the north and south. But since Pease AFB closed recently, Portland, Maine (PWM) was used instead. For winds from the northwest or southeast, the pressure difference between Plattsburgh AFB, New York (PBG) and Niagara Falls, New York (IAG) was used. For winds from the west or east, we used the pressure difference between Plattsburgh and La Guardia IAP, New York (LGA).

The customer also asked for an evaluation of an 11-millibar or greater pressure difference between any pair of stations as an indicator of current wind gusts equal to or greater than 35 knots. Surface weather observations for 1973 to 1989 (described in Section 2) were used. Section 3 discusses how linear regression equations were developed using 3-hourly data (i.e., 00Z, 03Z, and so forth) to obtain statistical predictions of the highest wind speed (including gusts) in the next 6 hours (*MAXPDWND*), based on pressure difference from any 3-hourly start time. In linear regression, *MAXPDWND* was the *predictand* (the predicted variable) and pressure difference was the *predictor*. To evaluate an 11-millibar or greater pressure difference as an indicator of 35-knot or higher winds, wind speed frequency distributions for the 11-millibar threshold value were produced for the specified directions. Results showed the 11-millibar or greater pressure difference to be a poor indicator of winds equal to or greater than 35 knots. However, linear regression results showed that each of the three pressure differences had some skill in predicting the maximum wind speed at Westover for 6-hour periods from forecast start times of 00Z plus every 3 hours. The study was therefore expanded to include other atmospheric variables.

1.4 The Expanded Study. To improve on the linear regression results in the basic study, we used procedures from Miller (1990)--see Section 3. The highest wind speed (including gusts) recorded at Westover in the 6-hour period following each 3-hourly observation time (*MAXPDWND*) was correlated with several variables valid at the same 3-hourly time. These variables included: (1) the highest observed Westover wind speed (including gusts) at each 3-hourly time, (2) Westover wind direction, (3) Westover sea-level pressure, (4) the other stations' sea-level pressures, and (5) the pressure differences appropriate to the wind direction category. In linear regression, *MAXPDWND* was the *predictand*; the other variables were the *predictors* used to obtain predictive equations for *MAXPDWND* occurring within 6 hours after any 3-hourly start time. Another technique, one that compared pressure differences for two of the station pairs (oriented roughly perpendicular to each other) and *MAXPDWND*, was also developed. This technique was used to evaluate the skill of using a conditional mean *MAXPDWND* (based on the two pressure differences) as a predictor of wind speed at Westover for 6 hours after each 3-hourly observation.

1.5 Findings. When used alone as a Westover wind speed predictor for 6-hour periods starting at 3-hourly times, pressure difference performed poorly; a pressure difference threshold of 11 millibars was *not* useful as an indicator of wind gusts equal to or greater than 35 knots. But by adding variables to the linear regressions, the skill in predicting wind speeds for 6-hour periods starting at any 3-hourly time increased considerably. The method in which the mean *MAXPDWND* associated with observed 3-hourly pressure differences at two of the station pairs was used as a 6-hour wind-speed predictor at Westover was shown to be ineffective. Verification of this method and the various wind-speed equations (models) are discussed in Section 4. The five models that performed best are shown as Equations 1-5 in Figure 2. They are recommended for use in making 6-hour maximum wind speed forecasts for Westover starting at 00Z plus every 3 hours for all seasons.

FIVE RECOMMENDED EQUATIONS FOR FORECASTING WESTOVER AFB WINDS

NORTH (320° clockwise to 040°) or _SOUTH_ sectors (140° clockwise to 220°)

$$MAXPDWND = 0.40 + 1.30\,(MAXWND) \qquad (1)$$

where *MAXPDWND* is the highest wind speed in knots predicted for any 6-hour period starting at any 3-hourly time, and *MAXWND* is the maximum wind speed in knots valid at the 3-hourly time.

NORTHWEST (270° clockwise to 360°) or _SOUTHEAST_ sectors (090° clockwise to 180°)

$$MAXPDWND = -0.11 + 0.93\,(MAXWND) + 0.30\,(PDPWMBGM) - 3.57\cos(WDIR) \qquad (2)$$

and

$$MAXPDWND = -0.59 + 0.93\,(MAXWND) + 0.30\,(PDPWMBGM)$$

$$- 3.53\cos(WDIR) + 0.88\,(HRDUM) \qquad (3)$$

where *PDPWMBGM* is the pressure difference in millibars between Portland and Binghamton, *WDIR* is wind direction in whole degrees (1 to 360), and *HRDUM* is a dummy variable to account for the time of day. If the forecast time is from 21Z to 09Z, *HRDUM* is equal to 1; otherwise, it is zero. All predictors are valid at the 3-hourly time. *Negative* values of *MAXPDWND* identify winds from the *northwest* sector.

WEST (220° clockwise to 320°) or _EAST_ sectors (040° clockwise to 140°)

$$MAXPDWND = -2.03 + 0.92\,(MAXWND) + 0.29\,(PDPBGLGA) + 0.45\,(PDPWMBGM) + 2.25\,(HRDUM) \qquad (4)$$

where *PDPBGLGA* is the pressure difference in millibars between Plattsburgh AFB and LaGuardia. *Negative* values of *MAXPDWND* identify winds from the *west* sector.

SOUTHWEST (180° clockwise to 270°) or _NORTHEAST_ sectors (360° clockwise to 090°):

$$MAXPDWND = -1.58 + 0.98\,(MAXWND) + 0.32\,(PDPBGLGA)$$
$$+ 2.95\cos(WDIR) + 2.16\,(HRDUM) \qquad (5)$$

Negative values of *MAXPDWND* identify winds from the *southwest* sector.

Figure 2. Five Recommended Equations for Forecasting Westover AFB Winds in the Sectors Specified.

2. DATA

2.1 Database. USAFETAC's DATSAV database was used to obtain hourly and special surface weather observation data from station file tapes for the reporting stations shown in Table 1. The period of record for all stations was from 1973 to 1989. All stations operated full-time during the period of record, except Westover, which was part-time (0700 to 2300 local) from February 1976 through October 1988. The effects of that part-time operation, however, were minimal, as will be discussed in Section 4.

TABLE 1. Reporting Stations. Period of Record: 1973-89.

Station	ICAO Identifier	Latitude	Longitude	Elevation (Meters)
Binghamton, NY	BGM	42° 13′N	75° 59′W	497
La Guardia, NY	LGA	40° 46′N	73° 54′W	9
Niagara Falls, NY	IAG	43° 06′N	78° 57′W	180
Plattsburgh AFB, NY	PBG	44° 39′N	73° 28′W	72
Portland, ME	PWM	43° 39′N	70° 19′W	19
Westover AFB, MA	CEF	42° 12′N	72° 32′W	75

2.2 Selected Variables. Enough atmospheric variables were chosen to complete the basic correlation of surface wind speed at Westover with pressure differences. The surface wind speeds, gusts, and wind directions were selected for Westover, along with the sea-level pressures for the other five stations. More Westover variables (sea-level pressure, temperature, ceiling height, present weather, and wind direction) were selected for correlation with Westover winds.

2.3 Quality Control. We used two procedures to eliminate bad data. First, we examined frequency distributions for each variable to detect questionable values. After checking these values in the appropriate observations, they were deleted if obviously erroneous. Second, we deleted observations if severe weather (such as a thunderstorm) was present. These two quality control methods resulted in the removal of less than 1 percent of the total observations.

2.4 Dependent and Independent Datasets. The data for 1973 to 1986 was used as the *dependent* dataset used to obtain the correlations, linear regressions, and other evaluations described in Section 3. As an independent check, data from 1987 to 1989 was used to test results from the dependent dataset.

3. METHODOLOGY

3.1 Basic Approach. One objective of this study was to determine the correlation of pressure differences for three pairs of stations with current wind speed at Westover. The particular pair of stations chosen to calculate pressure differences depended on the wind direction sector. The correlations of pressure differences with wind speed are discussed in Section 3.2, while Section 3.3 describes the linear regression used to obtain equations relating wind speed to pressure difference for the various wind direction sectors. The regression equations were tested with the independent dataset described in Section 3.4. Another objective of the study was to determine the usefulness of a pressure difference of 11 millibars or more for any pair of stations as an indicator of wind gusts equal to or greater than 35 knots occurring at the same time. Section 3.5 tells how frequency distributions of wind speed and the 11-millibar pressure difference threshold were evaluated.

3.1.1 Calculations. After quality-controlling the data, hourly and special weather observations were used to calculate the pressure differences for the three pairs of stations shown in Figure 1 for specific wind direction sectors at Westover as shown below.

For winds from 320° clockwise to 040° (north sector) or from 140° clockwise to 220° (south sector), where *PDPWMBGM* is the pressure difference in millibars between sea-level pressures at Portland (PWM) and Binghamton (BGM):

$$PDPWMBGM = SLPPWM - SLPBGM \tag{6}$$

For winds from 270° clockwise to 360° (northwest sector) or from 090° clockwise to 180° (southeast sector) where *PDPBGIAG* is the pressure difference in millibars between sea-level pressures at Plattsburgh (PBG) and Niagara Falls (IAG):

$$PDPBGIAG = SLPPBG - SLPIAG \tag{7}$$

For winds from 220° clockwise to 320° (west sector) or from 040° clockwise to 140° (east sector) where *PDPBGLGA* is the pressure difference in millibars between sea-level pressures at Plattsburgh (PBG) and La Guardia (LGA):

$$PDPBGLGA = SLPPBG - SLPLGA \tag{8}$$

3.1.2 Negative Pressure Differences = Negative Wind Speeds. To facilitate the correlations and linear regressions described in the next section, the sign of the wind speed was made negative depending on the wind direction. Negative *wind speeds* coincide with negative *pressure differences*. In Westover's terminal forecast reference file, a 1947 study shows the typical winter and summer synoptic situations. For most arrangements of surface pressure systems, the following statements about pressure differences apply:

- When winds at Westover are from the *north* sector, *PDPWMBGM* is negative due to lower pressure at PWM.
- When winds at Westover are from the *northwest* sector, *PDPBGIAG* is negative due to lower pressure at PBG.
- When winds at Westover are from the *west* sector, *PDPBGLGA* is negative due to lower pressure at PBG.

Accordingly, all wind speeds from the north, northwest, and west sectors were made negative. For example, a wind speed of 10 knots from 360° was used as -10 knots in calculations, while a 10-knot speed from 180° remained positive.

3.2 Correlations. Since correlations demonstrate the linear dependency between variables, it was advantageous to use negative values of wind speed in correlations with pressure differences when pressure differences were also negative. In this way, the linear integrity of the data is preserved. In the ideal case of correlation, all the plotted data (wind speed versus pressure difference) would lie along a straight line, and the correlation coefficient would be 1.0 or -1.0, representing total linear dependence between the two variables. A correlation coefficient of zero, on the other hand, would indicate that the variables were linearly *independent*. Initially, data for the same time was correlated, but further work used the correlation between variables at the forecast time and the maximum wind speed during the following 6 hours.

We used the Pearson product-moment correlation method for this study. The pressure differences defined in Equations 6 through 8 were correlated with wind speed (excluding gusts) using the dependent dataset. The correlation coefficients in Table 2 show weak linear dependence of wind speed on the three pressure differences. The fact that all three correlations are positive shows that as pressure difference increases, so does wind speed. This does not imply, however, that the increase is linear. In a study of wind speed and pressure gradients by Brenner (1980), plots of sustained wind speed above 8 knots versus pressure gradients showed that the two acted in a nonlinear fashion. Essenwanger (1986) also pointed out that low correlation coefficients may be due in part to nonlinear relationships between variables.

TABLE 2. Correlations of Sea-level Pressure (SLP) Difference (mb), with Wind Speeds (kts) in Three Wind Direction Categories at Westover AFB. Period of Record: 1973-86.

Pressure Differences (mb)	Direction Sectors	Correlation Coefficients
PDPWMBGM[1]	N (320° - 040°) or S (140° - 220°)	0.30
PDPBGIAG[2]	NW (270° - 360°) or SE (090° - 180°)	0.45
PDPBGLGA[3]	W (220° - 320°) or E (040° - 140°)	0.41

1. *PDPWMBGM* Portland SLP minus Binghamton SLP
2. *PDPBGIAG* Plattsburgh SLP minus Niagara Falls SLP
3. *PDPBGLGA* Plattsburgh SLP minus La Guardia SLP

3.3 Linear Regressions. Although the low correlations were not encouraging, we tried to develop predictive equations for wind speed by linear regression. As a first step, following Miller's (1990) approach, all the observations for Westover were used to produce a 3-hourly database to use for regression analysis. The value of the highest wind speed (including gusts) for an observation was called *MAXWND*. As an example, with an observed wind from 360° at 12 knots with gusts to 25 knots, *MAXWND* is 25 knots. Next, for every 6-hour period starting with 0000Z and each 3-hourly thereafter, the highest *MAXWND* was selected from hourly and special observations and called *MAXPDWND* As a result, every 3-hourly observation for Westover was assigned a *MAXPDWND* that represented the highest wind speed observed in the 6 hours following the 3-hourly observation. The linear regression was used on 3-hourly data to obtain predictive equations for the maximum wind speed (*MAXPDWND*) at Westover occurring 6 hours from forecast start times of 00Z plus every 3 hours. In linear regression, a best-fit straight line is determined for plots of a predictand and predictor(s). The predictand in this case is *MAXPDWND* and the predictor is pressure difference. To illustrate, the equation for a line is given by

$$y = b + mx \tag{9}$$

where y is the predictand (dependent variable), b a constant, m the slope of the line, and x the predictor (independent variable). From linear regression with 3-hourly data from the dependent data set (1973-1986), the following equations were obtained to predict the maximum wind speed at Westover for 6 hours starting at any 3-hourly time in any season; note that in using equations 10 through 12, the units of pressure difference must be in millibars so that the calculated wind speed is in knots. Negative wind speeds are interpreted as coming from the north, northwest, or west sectors, respectively.

Model A:

$$MAXPDWND = 0.26 + 0.51\,(PDPWMBGM) \tag{10}$$

where *MAXPDWND* is the predicted wind speed in knots at Westover for 6 hours from any 3-hourly time for winds from either the north (320° - 040°, negative) or south (140° - 220°) sector, and *PDPWMBGM* is the pressure difference in millibars observed at the forecast start time.

Model B:

$$MAXPDWND = -2.77 + 0.76\,(PDPBGIAG) \tag{11}$$

where *MAXPDWND* is the predicted wind speed in knots at Westover for 6 hours from any 3-hourly time for winds from either the northwest (270° - 360°, negative) or southeast (090° - 180°) sector, and PDPBGIAG is the pressure difference in millibars observed at the forecast start time.

Model C:

$$MAXPDWND = -4.07 + 0.82\,(PDPBGLGA) \tag{12}$$

where *MAXPDWND* is the predicted wind speed in knots at Westover for 6 hours from any 3-hourly time for winds from either the west (220° - 320°, negative) or east (040° - 140°) sector, and *PDPBGLGA* is the pressure difference in millibars observed at the forecast start time.

3.4 Testing the Regression Equations. To determine how accurately equations 10 through 12 (Models A, B, and C) predict *MAXPDWND*, they were tested using both the dependent (1973-86) and independent (1987-89) datasets--the results are given in Section 4. These equations were used to predict wind speed for 6-hour periods starting at 00Z plus every 3 hours by using the appropriate pressure difference at the start time in the model applicable to the expected wind direction. In analysis, the predicted *MAXPDWND* was compared to the highest observed wind speed (including gusts) in each 6-hour period. For convenience of analysis, the observed and predicted wind speeds were put in 10-knot categories (calm to 9 knots, 10 to 19 knots, and so forth) up to 70 to 79 knots. For winds from the north, northwest, or west sectors, the speeds were signed negative as was discussed earlier. For these sectors, categories ranged from -1 to -10 knots up to -71 to -80 knots. Once categorized, frequency tables of observed and predicted wind speeds were produced, and statistics were calculated to measure the relative capabilities of each model in predicting wind speed. These statistics included:

Coefficient of Determination (R^2). R^2 is the square of the correlation coefficient. It ranges from 0 to 1 and shows how much variability in the dependent variable (wind speed) is accounted for by the independent variable (pressure difference). An R^2 of zero shows that the variables are unrelated, while a 1 indicates total dependency between the variables.

Heidke Skill Score (HSS). The HSS measures the ability of a model to predict more accurately than climatological chance. It ranges from negative one to plus one; negative one indicates no skill, and plus one indicates perfect skill.

Critical Success Index (CSI). The CSI is the ratio of the number of correct predictions to the sum of the hits, misses, and false alarms. Hits are correct predictions, misses are events that happened but were not predicted, and false alarms are predicted events that did not happen. The CSI ranges from zero to one, where one is perfect.

3.5 Wind Gusts and Pressure Differences. Pressure differences equal to or greater than 11 millibars were evaluated as indicators of wind gusts equal to or greater than 35 knots occurring at the same time. Using the north and south wind direction sectors as examples, the absolute values of all observed *PDPWMBGM* were categorized according to whether they were less than the 11-millibar threshold value or equal to or greater than the threshold value. If they were less than the threshold value, a wind-gust value of less than 35 knots was assigned; if greater, they were assigned a wind-gust value equal to or greater than 35 knots. The actual observed wind gust speeds were categorized as either less than 35 knots or equal to or greater than 35 knots. Next, the actual wind gust speeds for each *PDPWMBGM* were compared in a frequency table with the assigned gust speeds. The same procedure was followed for the other wind direction sectors and the applicable pressure differences. The results were verified using both the dependent and independent data sets using HSS and CSI as measures. As will be shown in Section 4, verification results for the wind-gust indicator and basic regression Models A, B, and C (see 3.3, above) for *MAXPDWND* were not favorable, and the study was expanded in an effort to obtain more suitable regression models.

3.6 The Expanded Approach. Because of the unfavorable results obtained from using pressure difference alone as a predictor for maximum wind speeds, the approach was expanded to add more predictor variables to the linear regressions. The 3-hourly observations for Westover and the other stations were used to correlate the additional predictor variables with *MAXPDWND*, as will be discussed in 3.8. The *MAXPDWND* was used as the predictand in the regressions to be discussed in 3.9. The intent was to obtain regression models that would better help predict wind speeds during the first 6 hours of a forecast period starting at any 3-hourly time.

3.7 Additional Predictor Variables. To optimize linear regression to obtain predictive equations for *MAXPDWND*, the following additional predictor variables from the datasets of 3-hourly observations were added to the three pressure differences in the basic study:

WDIR - current observed wind direction at Westover (whole degrees). The wind direction is expressed as cos (*WDIR*) to account for the discontinuity at 360°. The value ranges from-1 to 1.

CIGHGT - current observed ceiling height at Westover (feet).

WX2 - present weather at Westover.

TEMP - current observed surface temperature at Westover (°F).

DELP24 - change in surface pressure at Westover over the last 24 hours (mb).

DELT24 - change in surface temperature at Westover over the last 24 hours (°F).

SLPCEF - current observed sea-level pressure at Westover (mb).

SLPPBG - current observed sea-level pressure at Plattsburgh (mb).

SLPIAG - current observed sea-level pressure at Niagara Falls (mb).

SLPBGM - current observed sea-level pressure at Binghamton (mb).

SLPLGA - current observed sea-level pressure at La Guardia (mb).

HRDUM - a dummy variable to take time of day into consideration.

MAXWND - current maximum reported wind speed or gust (kt).

The *TEMP*, *DELP24*, *DELT24*, and *SLPCEF* variables were thought to be useful whenever Westover winds were influenced by fronts. *HRDUM* allows the time of day to be taken into consideration; this is important because winds are typically strongest between 21Z and 09Z. *HRDUM* is set to 1 for hours between 21Z and 09Z and to zero for other hours.

3.8 Correlation Results. The predictor variables listed above were correlated with the predictand variable (*MAXPDWND*) using the Pearson product-moment correlation method to determine the degree of linear dependency of each. As was done previously, the values of *MAXWND* and *MAXPDWND* were made negative for winds from the north, northwest, and west sectors. For completeness, the southwest (180° to 270°) and northeast (360° to 090°) sectors were included (The values of *MAXWND* and *MAXPDWND* were also made negative for winds in the southwest sector). The correlation results are shown in Table 3. As expected, the *MAXWND* correlated best with *MAXPDWND* in all sectors. In most cases, the pressure differences (*PPDWMBGM*, *PDPBGIAG*, and *PDPBGLGA*) and wind direction (*WDIR*) also correlated well with *MAXPDWND*.

TABLE 3. Correlations of Independent Variables with *MAXPDWND*. Period of Record: 1973-86.

	WIND SECTOR CATEGORIES			
VARIABLE	N/S	NW/SE	W/E	SW/NE
MAXWND	0.91	0.91	0.88	0.88
PDPWMBGM	0.34	0.68	0.76	0.37
PDPBGIAG	0.11	0.52	0.68	0.42
PDPBGLGA	-0.66	-0.23	0.45	0.72
WDIR	-0.84	-0.70	-0.10	0.74
HRDUM	0.03	0.11	0.12	0.07
SLPCEF	-0.01	0.19	0.31	0.22
SLPIAG	-0.39	-0.31	-0.14	0.20
SLPBGM	-0.21	-0.09	0.04	0.17
SLPPWM	0.01	0.35	0.52	0.36
SLPLGA	0.02	0.10	0.12	0.06
CIGHGT	-0.06	-0.16	-0.19	-0.11
WX2	-0.02	0.15	0.26	0.18
TEMP	0.32	0.31	0.17	-0.18
DELP24	-0.21	-0.15	-0.02	0.14
DELT24	0 30	0.23	0.05	-0.24

3.9 Multiple-Variable Linear Regressions. Predictive equations for *MAXPDWND* for 6-hour periods following any 3-hourly time were obtained for each of the four wind direction sector categories through a combination of automated statistical procedures and experimentation. Given a list of independent variables, the automated procedures selected the best independent variables to use as predictors and produced regression equations for the best single variable, the best two variables, and so forth. With the automated results used as a guide, several experiments were done with different combinations of predictor variables. Based on skill scores, as discussed in Section 4, the best one-variable, two-variable, three-variable, and four-variable regression models were obtained. These models (A1 through D4) are listed in Table 4 for the N/S, NW/SE, W/E, and SW/NE sectors.

The choice of a four-variable limit for regression models was based on the fact that adding more independent variables did not add to any model's ability to describe variability in the *MAXPDWND*. It should also be noted that even though an independent variable correlated well with *MAXPDWND*, it was not necessarily a good one to use in regression. As an example from the correlations in Table 3 for the NW/SE sector, *SLPPWM* correlated better with *MAXPDWND* than did *HRDUM*. But in the automated selection procedure, *HRDUM* was chosen over *SLPPWM* because it contributed more to the overall model.

TABLE 4. Best Single- and Multiple-Variable Models for Predicting *MAXPDWND*. Developed from the Period of Record: 1973-86.

N/S SECTORS

A1 $MAXPDWND = 0.40 + 1.30\ (MAXWND)$

A2 $MAXPDWND = 0.32 + 0.96\ (MAXWND) - 4.12 \cos (WDIR)$

A3 $MAXPDWND = 0.84 + 0.96\ (MAXWND) - 4.16 \cos (WDIR) - 1.05\ (HRDUM)$

A4 $MAXPDWND = 0.90 + 0.94\ (MAXWND) + 0.07\ (PDPWMBGM) - 4.28 \cos (WDIR) - 1.04\ (HRDUM)$

NW/SE SECTORS

B1 $MAXPDWND = -0.30 + 1.24\ (MAXWND)$

B2 $MAXPDWND = -0.39 + 1.07\ (MAXWND) - 3.33 \cos (WDIR)$

B3 $MAXPDWND = -0.11 + 0.93\ (MAXWND) + 0.30\ (PDPWMBGM) - 3.57 \cos (WDIR)$

B4 $MAXPDWND = -0.59 + 0.93\ (MAXWND) + 0.30\ (PDPWMBGM) - 3.53 \cos (WDIR) + 0.88\ (HRDUM)$

W/E SECTORS

C1 $MAXPDWND = -1.09 + 1.21\ (MAXWND)$

C2 $MAXPDWND = -1.03 + 0.97\ (MAXWND) + 0.46\ (PDPWMBGM)$

C3 $MAXPDWND = -2.29 + 0.96\ (MAXWND) + 0.47\ (PDPWMBGM) + 2.41\ (HRDUM)$

C4 $MAXPDWND = -2.03 + 0.92\ (MAXWND) + 0.29\ (PDPBGLGA) + 0.45\ (PDPWMBGM) + 2.25\ (HRDUM)$

SW/SE SECTORS

D1 $MAXPDWND = -0.95 + 1.31\ (MAXWND)$

D2 $MAXPDWND = -0.78 + 1.07\ (MAXWND) + 3.41 \cos (WDIR)$

D3 $MAXPDWND = -0.53 + 0.97\ (MAXWND) + 0.35\ (PDPBGLGA) + 2.87 \cos (WDIR)$

D4 $MAXPDWND = -1.58 + 0.98\ (MAXWND) + 0.32\ (PDPBGLGA) + 2.95 \cos (WDIR) + 2.16\ (HRDUM)$

3.10 The Two-Pressure-Difference Model. Based on a forecast study at K. I. Sawyer AFB, MI, by CMSgt Roger Graffa (USAF, Ret), another method for predicting winds was identified. In this, the "two-pressure-difference model," pressure differences from two station pairs near K.I. Sawyer and roughly perpendicular to each other were used, along with observed wind speed and direction at the base. One pressure difference was plotted on the *y*-axis, the other on the *x*-axis. The observed wind speed for the same time was plotted at the intersection of the two pressure differences. After a month of plotting data, lines of equal wind speed were analyzed. The result, based on 2 years of data, was a diagram of mean wind speeds based on pressure differences between two station pairs. A weather forecaster who knows the expected pressure differences between the station pairs could use this diagram to estimate wind speed. Figure 3 shows the results of applying the speed model to Westover from the 1973-86 period of record. To use the figure, locate the value of *PDPWMBGM* on the horizontal *x*-axis and the value of PDPBGLGA on the vertical. The two pressure differences intersect at the mean value of the highest 6-hour wind speed in knots following any 3-hourly time in any season.

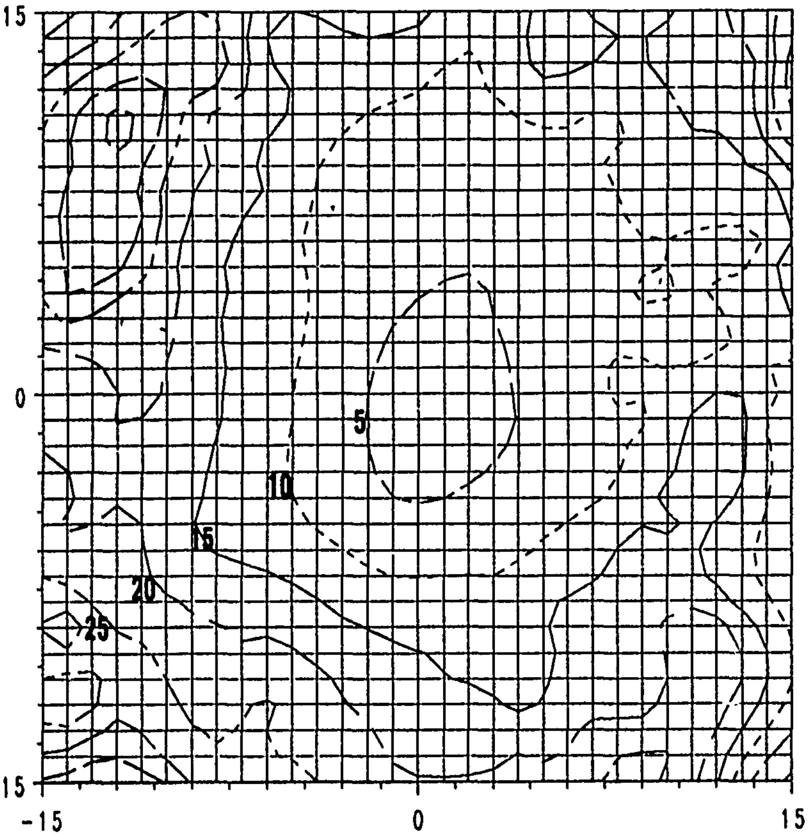

Figure 3. Results of Two-Pressure-Difference Model At Westover. The horizontal axis gives values of the pressure differences (mb) between Portland, ME, and Binghamton, NY. The vertical axis gives pressure differences (mb) between Plattsburgh AFB, NY, and LaGuardia IAP, NY. The contours are isolines of highest observed wind speed in 6-hour periods following any 3-hourly time in any season. Period of record: 1973-86.

To evaluate this method for Westover, *PDPBGLGA* and *PDPWMBGM* were used as the two-pressure-difference station pairs. Observations from the dependent dataset were used to compare *MAXPDWND* values for all wind directions with the two pressure differences. The resultant mean value of all *MAXPDWND* for each 10-knot speed category was used as the predicted speed for 6 hours following any 3-hourly time. Then the actual observed values of *MAXPDWND* for each category were compared with the predicted speeds.

3.11 Testing Procedures. The models shown in Table 4 were tested as described in Section 3.4. The proposed models were used to predict wind speeds for 6-hour periods following all 3-hourly times in both the dependent and independent data sets. The predicted and observed wind speeds were placed into 10-knot categories sufficient to display all wind speeds. Frequency tables of predicted and observed speeds were produced, and statistics were calculated to evaluate each model's performance.

3.11.1 The "Inflation Factor." In an effort to improve the model wind speed forecasts, an "inflation factor," given in the following equation, was used:

$$S_i = \frac{(S_o - S_{bar})}{R} + S_{bar} \tag{13}$$

where S_i is the inflated wind speed, S_o is the original forecast, S_{bar} is the mean wind speed from the dependent data set, and R is the multiple correlation coefficient from the regression. The inflation factor is often helpful in forecasting higher wind speeds. It increases the speeds of winds above the mean value and decreases them below the mean.

3.11.2 Verification Results. Section 4 gives verification results for the models in Table 4 (with and without inflation), as well as for the two-pressure-difference model. Each model was evaluated on its ability to predict maximum wind speed for 6-hour periods following any 3-hourly time. Evaluations were made with predicted and observed wind speeds categorized in two ways: in 10-knot categories, and in categories of less than 35 knots or equal to or greater than 35 knots.

4. RESULTS

4.1 Model Verification. The models discussed in this study were evaluated by measuring their accuracy in predicting maximum wind speeds for 6-hour periods starting at any 3-hourly time. The 11-millibar pressure-difference threshold for gusts at or above 35 knots was evaluated by comparing every observation of pressure difference to every coinciding observation of wind speed at Westover. The model forecasts were first verified against observed wind speeds in the dependent dataset (1973-86), and then with observations in the independent dataset (1987-89). The coefficient of determination (R^2), Heidke Skill Score (HSS), and Critical Success Index (CSI) were used to verify the forecasts. The results follow.

4.1.1 First Verification--Pressure Differences Alone. The linear regression models developed to predict maximum wind speeds at Westover for 6 hours following any 3-hourly start time with pressure differences alone as predictors performed poorly, as shown in Table 5. Heidke skill scores and percent correct were based on 10-knot categories. The low R^2 values show that models A, B, and C can account for only up to 25 percent of the variability in wind speed, and HSS values show that the models are only a little better than chance.

TABLE 5. Verification of *MAXPDWND* Predictions: Models A, B, and C. Percent correct is denoted by "PCOR," and sample size by "OBS."

	Dependent Data Set (1973-86)				Independent Data Set (1987-89)			
*Model	R^2	HSS	PCOR	OBS	R^2	HSS	PCOR	OBS
A	0.11	0.16	48	15,099	0.16	0.20	53	3,874
B	0.24	0.20	55	14,880	0.25	0.25	64	3,092
C	0.18	0.14	57	10,907	0.25	0.25	65	2,454

*Model A: *MAXPDWND* = 0.26 + 0.51 (*PDPWMBGM*)
Model B: *MAXPDWND* = -2.77 + 0.76 (*PDPBGIAG*)
Model C: *MAXPDWND* = -4.05 + 0.82 (*PDPBGLGA*)

4.1.2 Verification of Pressure Differences ≥ 11 Millibars. Table 6 shows poor results in using 11-millibar or greater pressure differences between station pairs for specified wind direction sectors to forecast wind gusts equal to or greater than 35 knots.

TABLE 6. Verification of Occurrences of Wind Gusts ≥ 35 Kts with the Absolute Value of a Pressure Difference ≥ 11 Millibars by Directional Category.

WIND	Dependent Data Set (1973-86)				Independent Data Set (1987-89)			
SECTOR*	R^2	HSS	CSI	OBS	R^2	HSS	CSI	OBS
N/S	0.08	0.03	0.02	65,301	0.09	0.02	0.01	15,913
NW/SE	0.14	0.04	0.02	34,060	0.15	0.00	0.00	10,546
W/E	0.05	0.03	0.02	29,278	0.03	0.00	0.00	10,479

**PDPWMBGM* used for N/S sectors; *PDPBGIAG* for NW/SE, and *PDPBGLGA* for W/E.

Table 7 further illustrates the poor performance of an 11-millibar pressure difference threshold value as an indicator of coincident gusts at and above 35 knots. The table gives frequencies from the independent data set for the north-south wind sectors of observed winds below 35 knots and at or above 35 knots versus results of an 11-millibar threshold value for *PDPWMBGM*. It shows that from a total of 15,903 observed winds of less than 35 knots, the 11-millibar pressure difference threshold predicted 15,204 when it was below 11 millibars, but that it produced 699 false alarms when it was equal to 11 millibars or more. Gusts at or above 35 knots did not occur, giving a false-alarm rate of 0.98. Of the 10 observed speeds at or above 35 knots, it hit six when it was equal to 11 millibars or more (for a probability of detection of 0.60), but it missed four because it was less than 11 millibars.

TABLE 7. N/S Sector Wind Speeds < 35 Kts and ≥ 35 Kts, Observed vs. Indicated, Based on an 11-millibar Threshold Value for *PDPWMBGM*. From the independent data set: 1987-89.

Observed Wind	Wind Speed Indicated by 11-mb Threshold for *PDPWMBGM*		
Speeds	*Less than 35 kts*	*At or above 35 kts*	*TOTAL*
Less than 35 kts	15,204	699	15,903
At or above 35 kts	4	6	10
			15,913

4.1.3 Model Verification, Multiple-Variable Linear Regresssion. The models that used multiple-variable linear regression produced the most accurate forecasts of wind speeds at Westover for 6 hours following any 3-hourly start time. Tables 8-11 show dependent and independent verification results, sector by sector, for each group of models shown in Table 4.

Table 8 includes results without inflation. For comparison, Table 9 includes results *with* inflation. The performance of wind speed persistence is included. In using persistence, the observed maximum wind (*MAXWND*) at each 3-hourly time (00Z, 03Z, and so on) was compared to the highest wind speed (*MAXPDWND*) that occurred in the 6 hours following each 3-hourly time. In other words, *MAXWND* on each 3-hourly observation was persisted as the forecast for the next 6 hours, and compared to *MAXPDWND* for the next 6 hours. The models were verified using the Heidke Skill Score (HSS) and the percent of correct wind speed predictions for all of the 10-knot wind-speed categories. The HSS for persistence was included for comparison.

All the models listed in Table 4 were also evaluated for their accuracy in predicting wind gusts below 35 knots and equal to or greater than 35 knots. As in the verifications for all wind speeds, persistence was included in the gust verification. Tables 10 and 11 show the dependent and independent verifications without inflation and with inflation, respectively. The models were verified using the HSS and CSI. The HSS for persistence was included.

TABLE 8. Verification of Models for Predicting the Highest Wind Speed in a 6-Hour Period (*MAXPDWND*), and Persistence Scores, Sector by Sector, *Without* Inflation. Percent correct (PCOR) is for all 10-knot categories. Sample size is denoted by OBS.

N/S SECTORS		Dependent Data Set (1973-86)			Independent Data Set (1987-89)			
Model	R^2	HSS	PCOR	OBS	R^2	HSS	PCOR	OBS
A1	0.83	0.75	70	15,738	0.81	0.75	74	3,996
A2	0.86	0.74	67	15,738	0.84	0.73	69	3,996
A3	0.86	0.74	67	15,738	0.84	0.74	69	3,996
A4	0.86	0.74	67	15,099	0.84	0.74	69	3,874
Persistence		0.75	75	15,738		0.75	78	3,996
NW/SE SECTORS								
B1	0.82	0.74	68	15,274	0.77	0.73	71	3,158
B2	0.84	0.73	66	15,274	0.80	0.72	69	3,158
B3	0.85	0.74	67	14,657	0.81	0.72	69	3,073
B4	0.86	0.74	67	14,657	0.81	0.73	69	3,073
Persistence		0.74	74	15,274		0.73	78	3,158
W/E SECTORS								
C1	0.77	0.71	66	11,308	0.75	0.72	70	2,546
C2	0.80	0.71	66	10,851	0.77	0.70	68	2,484
C3	0.81	0.72	68	10,851	0.78	0.71	70	2,484
C4	0.81	0.73	68	10,542	0.79	0.71	69	2,417
Persistence		0.71	72	11,308		0.72	77	2,546
SW/NE SECTORS								
D1	0.77	0.70	66	11,698	0.77	0.71	71	3,309
D2	0.79	0.69	65	11,698	0.80	0.71	70	3,309
D3	0.80	0.68	61	11,305	0.81	0.72	70	3,183
D4	0.81	0.73	70	11,305	0.81	0.73	71	3,183
Persistence		0.69	74	11,698		0.72	78	3,309

TABLE 9. Same as Table 8, but *with* inflation. Persistence scores, model R^2 values, and observations are repeated for continuity.

N/S SECTORS		Dependent Data Set (1973-86)				Independent Data Set (1987-89)		
Model	R^2	HSS	PCOR	OBS	R^2	HSS	PCOR	OBS
A1	0.83	0.73	65	15,738	0.81	0.73	69	3,996
A2	0.86	0.72	62	15,738	0.84	0.72	65	3,996
A3	0.86	0.72	62	15,738	0.84	0.72	64	3,996
A4	0.86	0.72	62	15,099	0.84	0.71	64	3,874
Persistence		0.75	75	15,738		0.75	78	3,996
NW/SE SECTORS								
B1	0.82	0.73	66	15,274	0.77	0.72	70	3,158
B2	0.84	0.72	62	15,274	0.80	0.70	66	3,158
B3	0.85	0.73	63	14,657	0.81	0.70	64	3,073
B4	0.86	0.73	64	14,657	0.81	0.71	65	3,073
Persistence		0.74	74	15,274		0.73	78	3,158
W/E SECTORS								
C1	0.77	0.70	64	11,308	0.75	0.70	68	2,546
C2	0.80	0.70	63	10,851	0.77	0.69	65	2,484
C3	0.81	0.72	65	10,851	0.78	0.70	67	2,484
C4	0.81	0.72	65	10,542	0.79	0.71	66	2,417
Persistence		0.71	72	11,308		0.72	77	2,546
SW/NE SECTORS								
D1	0.77	0.68	63	11,698	0.77	0.70	67	3,309
D2	0.79	0.67	60	11,698	0.80	0.68	63	3,309
D3	0.80	0.68	61	11,305	0.81	0.68	63	3,183
D4	0.81	0.69	62	11,305	0.81	0.70	65	3,183
Persistence		0.69	74	11,698		0.72	78	3,309

TABLE 10. Verification of Models for Predicting Wind Gusts < 35 Kts and $\geq$ 35 Kts, Sector by Sector, with Persistence Scores, *Without* Inflation. Sample size is denoted by OBS.

N/S SECTORS	Dependent Data Set (1973-86)				Independent Data Set (1987-89)			
Model	R^2	HSS	CSI	OBS	R^2	HSS	CSI	OBS
A1	0.83	0.32	0.20	15,738	0.81	0.32	0.19	3,996
A2	0.86	0.33	0.20	15,738	0.84	0.00	0.00	3,996
A3	0.86	0.31	0.19	15,738	0.84	0.00	0.00	3,996
A4	0.86	0.32	0.19	15,099	0.84	0.00	0.00	3,874
Persistence		0.27	0.15	15,738		0.00	0.00	3,996
NW/SE SECTORS								
B1	0.82	0.43	0.28	15,274	0.77	0.11	0.06	3,158
B2	0.84	0.47	0.31	15,274	0.80	0.07	0.04	3,158
B3	0.85	0.54	0.37	14,657	0.81	0.00	0.00	3,073
B4	0.86	0.54	0.37	14,657	0.81	0.00	0.00	3,073
Persistence		0.45	0.29	15,274		0.00	0.00	3,158
W/E SECTORS								
C1	0.77	0.44	0.29	11,308	0.75	0.00	0.00	2,546
C2	0.80	0.47	0.31	10,851	0.77	0.00	0.00	2,484
C3	0.81	0.47	0.31	10,851	0.78	0.00	0.00	2,484
C4	0.81	0.49	0.33	10,542	0.79	0.00	0.00	2,417
Persistence		0.47	0.31	11,308		0.00	0.00	2,546
SW/NE SECTORS								
D1	0.77	0.28	0.17	11,698	0.77	0.24	0.14	3,309
D2	0.79	0.25	0.15	11,698	0.80	0.00	0.00	3,309
D3	0.80	0.24	0.14	11,305	0.81	0.20	0.11	3,183
D4	0.81	0.25	0.14	11,305	0.81	0.22	0.13	3,183
Persistence		0.18	0.10	11,698		0.00	0.00	3,309

TABLE 11. Same as Table 10, but *with* Inflation. Persistence scores, model R^2 values, and observations are repeated for continuity.

N/S SECTORS	Dependent Data Set (1973-86)				Independent Data Set (1987-89)			
Model	R^2	HSS	CSI	OBS	R^2	HSS	CSI	OBS
A1	0.83	0.26	0.16	15,738	0.81	0.24	0.14	3,996
A2	0.86	0.34	0.21	15,738	0.84	0.00	0.00	3,996
A3	0.86	0.34	0.21	15,738	0.84	0.18	0.10	3,996
A4	0.86	0.34	0.21	15,099	0.84	0.20	0.11	3,874
Persistence		0.27	0.15	15,738		0.00	0.00	3,996
NW/SE SECTORS								
B1	0.82	0.35	0.22	15,274	0.77	0.17	0.10	3,158
B2	0.84	0.41	0.27	15,274	0.80	0.30	0.18	3,158
B3	0.85	0.46	0.31	14,657	0.81	0.16	0.09	3,073
B4	0.86	0.47	0.31	14,657	0.81	0.11	0.06	3,073
Persistence		0.45	0.29	15,274		0.00	0.00	3,158
W/E SECTORS								
C1	0.77	0.34	0.21	11,308	0.75	0.04	0.02	2,546
C2	0.80	0.37	0.24	10,851	0.77	0.05	0.03	2,484
C3	0.81	0.39	0.25	10,851	0.78	0.06	0.03	2,484
C4	0.81	0.40	0.26	10,542	0.79	0.07	0.04	2,417
Persistence		0.47	0.31	11,308		0.00	0.00	2,546
SW/NE SECTORS								
D1	0.77	0.23	0.14	11,698	0.77	0.16	0.09	3,309
D2	0.79	0.26	0.15	11,698	0.80	0.27	0.16	3,309
D3	0.80	0.28	0.16	11,305	0.81	0.37	0.23	3,183
D4	0.81	0.29	0.17	11,305	0.81	0.35	0.21	3,183
Persistence		0.18	0.10	11,698		0.00	0.00	3,309

4.1.4 Two-Pressure-Difference Model Verification. The two-pressure-difference model shown in Figure 2 was verified for all wind speeds, and separately for the two wind-gust categories. Because of its design, it was verified for all wind directions rather than for sectors. Persistence, (also for all directions) was included. Table 12 shows the results. The HSS and percent of correct wind speed predictions were used to verify all the 10-knot wind-speed categories; the HSS and CSI were used to verify the gust categories. The two-pressure-difference model for Westover did not perform as well as persistence. Essentially, it gives average values of the highest wind speed in a 6-hour period based on observed pressure differences over a long period of time. It cannot, therefore, compete with day-to-day persistence.

TABLE 12. Verification of Two-Pressure-Difference Model for Predicting the Highest Wind Speed in a 6-Hour Period (*MAXPDWND*); Wind Gusts < 35 Kts and ≥ 35 Kts, with Persistence Scores, All Wind Directions. Percent correct is denoted by PCOR; sample size is denoted by OBS.

	Dependent Data Set (1973-86)				Independent Data Set (1987-89)			
	R^2	HSS	PCOR	OBS	R^2	HSS	PCOR	OBS
All Speeds	0.38	0.39	66	29,198	0.29	0.36	71	9,106
Persistence		0.53	77	29,198		0.50	82	9,106
	R^2	HSS	CSI	OBS	R^2	HSS	CSI	OBS
< 35 kts and ≥ 35 kts	0.38	0.09	0.05	29,198	0.29	0.00	0.00	9,106
Persistence		0.38	0.24	29,198		0.00	0.00	9,106

4.2 Best Models. Based on the results shown in Tables 8 through 11, the five linear regression models shown as Equations 1-5 in Figure 2 were determined to be the most accurate in predicting the highest wind speeds in a 6-hour period starting at any 3-hourly time in any season at Westover.

For the north-south sectors, Model A1 (Equation 1) had the highest HSS and percent of correct predictions for wind speeds; it also had high HSS and CSI for wind gusts in the dependent and independent dataset verifications.

For the northwest-southeast sectors, Models B3 and B4 (Equations 2 and 3) outperformed persistence and had the highest HSS and CDI for wind gusts in the dependent dataset verifications.

For the west-east sectors, Model C4 (Equation 4) outperformed persistence and had the highest HSS and percent of correct predictions for wind speeds in the dependent dataset verifications. It also outperformed persistence and had the highest HSS and CSI for wind gusts in the dependent dataset verifications.

For the southwest-northeast sectors, Model D4 (Equation 5) was the best for predicting the highest wind speed in a 6-hour period. It outperformed persistence and had the highest HSS and percent of correct predictions in the dependent and independent dataset verifications. It also outperformed persistence in predicting gusts.

4.2.1 The Effects of Part-time Operations. As noted in Section 2, Westover operated part-time from February 1976 through October 1988. To find out if this affected the wind-speed model results, we tested the northwest-southeast with different dependent and independent datasets. The period from 1979 through 1983 was used as the dependent dataset, and the period of full-time operation from 1973 through 1975 was used as the independent dataset. The models developed with the 1979-83 data were almost identical to those generated with the 1973-86 data, and verification with the 1973-75 data confirmed that models B3 and B4 were the best. Based on this test, we concluded that the part-time operations at Westover during 1976-88 had little effect on the results of this study.

4.2.2 Sample Sizes. It should be pointed out that the HSS values in Tables 8 through 11 were influenced by the sample size. The independent HSSs are usually expected to be lower than the dependent dataset skill scores. However, if the independent sample size is smaller than the dependent sample size, there can be exceptions. In this study, the independent sample size was about 20 percent that of the dependent sample size. This explains those cases in which the independent HSS equaled or exceeded the HSS for the dependent dataset. Another factor of note is that the HSS and CSI in Tables 10 and 11 were heavily influenced by the placement of wind speeds in only two categories: one for speeds less than 35 knots, and the other for speeds at or over 35 knots. The intent was to focus on the ability of each model to predict gusts at or above 35 knots. Since the first category contained far more wind-speed observations than the second, false alarms and misses by the models in the second category quickly lowered the HSS and CSI.

4.2.3 "Inflation" Not Applicable to Westover. As shown in Tables 8 and 9, inflation decreased the skill of most of the models in predicting the highest wind speed in a 6-hour period. As discussed earlier, inflation increases the predicted values for the higher wind speeds at the expense of predictions for the lower wind speeds. For gust predictions (Tables 10 and 11), inflation results were mixed. Inflation increased the prediction skill slightly for some models in the N/S and SW/NE sectors in the dependent dataset, but decreased the skill for all models in the NW/SE and W/E sectors in the dependent dataset. It increased the gust prediction skill slightly for most models in all sectors in the independent dataset. Based on these results, we conclude that the use of inflation is not applicable to Westover.

5. SUMMARY

5.1 Discussion. The wind study for Westover AFB, Massachusetts, had two objectives. One was to evaluate pressure differences between three pairs of reporting stations in the area of Westover for their use in predicting maximum wind speeds from specific wind direction sectors for 6-hour periods starting on any 3-hourly time in any season. The other objective was to determine if a pressure difference of 11 millibars or more between any pair of reporting stations was a useful indicator of wind gusts of 35 knots or more occurring at the same time. When we concluded that neither of these models were useful, the study was expanded to find wind-speed prediction models that *would* be useful. Linear regression with single and multiple variables was used to develop models for forecasting maximum winds for 6-hour periods starting on any 3-hourly time; tests resulted in the selection of five useful models. A two-pressure difference model was also evaluated, but it did not provide useful wind speed forecasts.

5.2 Recommendations. USAFETAC recommends use of the following models as guides in forecasting maximum wind speeds for the first 6 hours of a forecast period starting at any 3-hourly time (00Z, 03Z, and so on) in any season for Westover. The recommended models are also given in Figure 2.

- Model A1 (Equation 1) for winds from the north or south sectors.
- Models B3 (Equation 2) and B4 (Equation 3) for winds from the northwest or southeast sectors.
- Model C4 (Equation 4) for winds from the west or east sectors.
- Model D4 (Equation 5) for winds from the southwest or northeast sectors.

Models A1, B3, B4, C4, and D4 may perform a little better than persistence in predicting wind gusts for 6-hour periods. If the result of Equations 2, 3, 4, or 5 is negative, it means that the wind speed is from the northwest, west, or southwest sector. When used with analysis of the synoptic situation, these models have potential for improving Westover AFB short-term wind speed forecasts.

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GLOSSARY

BGM	location identifier for Binghamton, New York
CEF	location identifier for Westover AFB, Massachusetts
CIGHGT	current observed ceiling height at Westover
CSI	Critical Success Index
DATSAV	USAFETAC's database of weather observations stored on magnetic tape
DELP24	change in surface pressure at Westover over the past 24 hours
DELT24	change in surface temperature at Westover over the past 24 hours
HRDUM	a dummy variable to take into consideration the hour of the day
HSS	Heidke Skill Score
IAG	location identifier for Niagara Falls, New York
ICAO	International Civil Aeronautic Organization
kt	knot
LGA	location identifier for La Guardia, New York
MAXPDWND	highest wind speed in a 6-hour period
MAXWND	maximum reported wind speed or gust
mb	millibar(s)
PBG	location identifier for Plattsburgh AFB, New York
PDPBGIAG	pressure difference between Plattsburgh AFB and Niagara Falls
PDPBGLGA	pressure difference between Plattsburgh AFB and La Guardia
PDPWMBGM	pressure difference between Portland and Binghamton
PWM	location identifier for Portland, Maine
R	multiple correlation coefficient
R^2	coefficient of determination
S_{bar}	mean wind speed from dependent data set
S_i	inflated wind speed
SLPBGM	current observed sea-level pressure at Binghamton, New York
SLPCEF	current observed sea-level pressure at Westover AFB, Massachusetts
SLPIAG	current observed sea-level pressure at Niagara Falls, New York
SLPLGA	current observed sea-level pressure at La Guardia IAP, New York
SLPPBG	current observed sea-level pressure at Plattsburgh AFB, New York
SLPPWM	current observed sea-level pressure at Portland, Maine
S_o	original wind speed forecast
TEMP	current observed surface temperature at Westover
WDIR	current observed wind direction at Westover
WSPD	wind speed, excluding gusts
WX2	present weather at Westover
Z	Zulu (Greenwich Mean Time)

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